

CLAIMS

1. A motor drive apparatus comprising:
 - a first drive circuit (14) driving a first motor (MG1); and
 - 5 a voltage converter (12) performing a voltage conversion between a power supply (B) and said first drive circuit (14), wherein
said first drive circuit (14) starts to drive said first motor (MG1) at a timing different from a timing at which said voltage converter (12) starts the voltage conversion.
- 10 2. The motor drive apparatus according to claim 1, wherein
said voltage converter (12) performs a voltage step-up operation of stepping up a power supply voltage to an arbitrary level and outputs the stepped-up voltage, and
said first drive circuit (14) starts to drive said first motor (MG1) in powering mode after said voltage converter (12) starts the voltage step-up operation.
- 15 3. The motor drive apparatus according to claim 2, wherein
said first drive circuit (14) starts to drive said first motor (MG1) in powering mode after said voltage step-up operation is completed.
- 20 4. The motor drive apparatus according to claim 3, wherein
said first drive circuit (14) receives, after said voltage step-up operation is completed, a required power of said first motor (MG1) and starts to drive said first motor (MG1) in powering mode.
- 25 5. The motor drive apparatus according to claim 4, wherein
said first drive circuit (14) holds in advance a relation between temperature of said power supply (B) and an electric power level that can be output from said power supply, and determines a timing at which said first motor (MG1) is started to be driven,

based on the temperature of said power supply.

6. The motor drive apparatus according to claim 5, wherein
when the temperature of said power supply is lower than a first predetermined
threshold or the temperature of said power supply is higher than a second predetermined
threshold, said first drive circuit (14) receives the required power of said first motor

5 threshold or the temperature of said power supply is higher than a second predetermined
threshold, said first drive circuit (14) receives the required power of said first motor
(MG1) after said voltage step-up operation is completed, and starts to drive said first
motor (MG1) in powering mode.

10 7. The motor drive apparatus according to claim 6, wherein
a predetermined delay time is provided between a timing at which said voltage
step-up operation is completed and a timing at which said first drive circuit (14) starts to
drive.

15 8. The motor drive apparatus according to any of claims 2 to 7, wherein
said first motor (MG1) is a motor starting or stopping an internal combustion
engine (ENG), and
said voltage converter (12) starts said voltage step-up operation when an
instruction to start said internal combustion engine (ENG) is output.

20 9. The motor drive apparatus according to claim 8, further comprising:
target voltage determination means (50) for determining a target voltage of said
stepped-up voltage based on the number of revolutions of said first motor (MG1); and
voltage conversion control means (52, 54, 56) receiving the target voltage
25 determined by said target voltage determination means (50) for controlling said voltage
converter (12) to set said stepped-up voltage to said target voltage, wherein
receiving said instruction to start said internal combustion engine (ENG), said
voltage conversion control means (52, 54, 56) controls said voltage converter (12) to

obtain a predetermined stepped-up voltage that is necessary for starting said internal combustion engine (ENG), regardless of said determined target voltage.

10. The motor drive apparatus according to claim 9, wherein
5 said predetermined stepped-up voltage is a maximum voltage of said motor drive apparatus.

11. The motor drive apparatus according to claim 10, wherein
10 said voltage conversion control means (52, 54, 56) determines a voltage step-up rate so that electric power required for said voltage step-up operation is within the electric power level that can be output from said power supply, and said power supply voltage is stepped up to said predetermined stepped-up voltage at said determined voltage step-up rate.

15 12. The motor drive apparatus according to claim 11, wherein
said voltage conversion control means (52, 54, 56) holds in advance a relation between temperature of said power supply and the electric power level that can be output from said power supply, and determines said voltage step-up rate based on the temperature of said power supply.

20 13. The motor drive apparatus according to claim 9, further comprising a second drive circuit (31) provided in parallel with said first drive circuit (14), and receiving said stepped-up voltage to drive a second motor (MG2), wherein
25 said target voltage determination means (50) determines said target voltage based on the number of revolutions of said first motor (MG1) or said second motor (MG2), and when said second motor (MG2) drives a vehicle and an instruction to start said internal combustion engine (ENG) is issued, said voltage conversion control means (52,

54, 56) controls said voltage converter (12) to obtain said predetermined stepped-up voltage before said internal combustion engine (ENG) is started.

14. The motor drive apparatus according to claim 13, wherein
5 said predetermined stepped-up voltage is a maximum voltage of said motor drive apparatus.

15. The motor drive apparatus according to claim 14, wherein
10 said voltage conversion control means (52, 54, 56) determines a voltage step-up rate so that electric power required for said voltage step-up operation is within the electric power level that can be output from said power supply, and steps up said power supply voltage at said determined voltage step-up rate to said predetermined stepped-up voltage.

15 16. The motor drive apparatus according to claim 15, wherein
said voltage conversion control means (52, 54, 56) holds in advance a relation between temperature of said power supply and the electric power level that can be output from said power supply, and determines said voltage step-up rate based on the temperature of said power supply.

20 17. The motor drive apparatus according to claim 1, wherein
after said first drive circuit (14) starts to drive said first motor (MG1) in regenerative mode, said voltage converter (12) starts a voltage step-down operation.

25 18. The motor drive apparatus according to claim 17, wherein
said voltage converter (12) starts said voltage step-down operation after said first drive circuit (14) drives said first motor (MG1) in said regenerative mode and stops said first motor.

19. The motor drive apparatus according to claim 18, wherein
said voltage converter (12) holds in advance a relation between temperature of
said power supply (B) and an electric power level that can be input to said power supply,

5 and determines a timing at which said voltage step-down operation is started, based on
the temperature of said power supply.

20. The motor drive apparatus according to claim 19, wherein
when the temperature of said power supply is lower than a first predetermined
10 threshold or higher than a second predetermined threshold, said first drive circuit (14)
starts said voltage step-down operation after stopping said first motor (MG1).

21. The motor drive apparatus according to claim 20, wherein
a predetermined delay time is provided between a timing at which said first
15 motor (MG1) is stopped and a timing at which said voltage step-down operation is
started.

22. The motor drive apparatus according to any of claims 17 to 21, further
comprising:

20 target voltage determination means (50) for determining a target voltage of an
output voltage of said voltage converter (12) based on the number of revolutions of said
first motor (MG1); and

25 voltage conversion control means (52, 54, 56) receiving the target voltage
determined by said target voltage determination means (50) for controlling said voltage
converter (12) to set said output voltage to said target voltage, wherein

when an instruction to stop said internal combustion engine (ENG) is output,
said first drive circuit (14) starts to drive said first motor (MG1) in said regenerative
mode, and

5 said voltage converter (12) starts said voltage step-down operation in response to completion of the stoppage of said internal combustion engine (ENG).

10 23. The motor drive apparatus according to claim 22, wherein
5 in response to the stoppage of said internal combustion engine (ENG), said voltage conversion control means (52, 54, 56) determines a voltage step-down rate so that electric power generated by said voltage step-down operation is within an electric power level that can be input to said power supply, and controls said voltage converter (12) to obtain said target voltage at said determined voltage step-down rate.

15 24. The motor drive apparatus according to claim 23, wherein
10 said voltage conversion control means (52, 54, 56) holds in advance a relation between temperature of said power supply and the electric power level that can be input to said power supply, and determines said voltage step-down rate based on the 15 temperature of said power supply.

20 25. The motor drive apparatus according to claim 22, further comprising a second drive circuit (31) provided in parallel with said first drive circuit (14) and receiving said output voltage to drive a second motor (MG2), wherein
25 said target voltage determination means (50) determines said target voltage based on the number of revolutions of said first motor (MG1) or said second motor (MG2), and
when said second motor (MG2) drives a vehicle and an instruction to stop said internal combustion engine (ENG) is issued, said voltage conversion control means (52, 54, 56) controls said voltage converter (12) to obtain said target voltage after said internal combustion engine (ENG) is stopped.